

informalities. As required by 37 C.F.R. § 1.121(b)(3)(iii) and § 1.125(b)(2), a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/EP00/08233 includes an International Search Report, dated December 12, 2000, and an International Preliminary Examination Report, dated October 26, 2001, copies of which are submitted herewith. The Search Report includes a list of documents that were considered by the examiner in the underlying PCT application. In addition, an English-language translation of the Preliminary Examination Report, including the annex, is enclosed herewith.

Applicants assert that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

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Dated: 2/25/02

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PROVISIONAL INTERNATIONAL REPORT OF EXAMINATION

I. Basis for the Report

1. With regard to the **component parts** of the international application (*substitute pages, which were submitted to the Patent Office in response to a request pursuant to Article 14, are considered within the framework of this report as "originally filed", and are not enclosed with the report, since they do not include any revisions (Regulations 70.16 and 70.17).*):

Specification, pages:

- | | |
|--------|--|
| 1,3-19 | original version |
| 2,2a | filed on 7/28/2001 with letter dated 7/20/2001 |

Patent Claims, no.:

- | | |
|--------------|--|
| 1,2,10-13,16 | original version |
| 3-9,14,15 | filed on 7/28/2001 with letter dated 7/20/2001 |

Drawings, pages:

- | | |
|---------|------------------|
| 1/3-3/3 | original version |
|---------|------------------|

III. No Provision of an Expert Report regarding Novelty, Inventive Activity, and Industrial Applicability

1. The following parts of the application were not examined with a view to whether the claimed invention is novel, is based on inventive activity (non-obvious), and is to be seen as industrially applicable:

Claims No. 4, 9, 10, 11, 12, 13.

Grounds:

The description, the Claims, or the drawings (*in this regard, give precise information below*) or the above-mentioned Claims No. 4, 9, 10, 11, 12, 13 are so unclear that no meaningful Expert Report could be prepared (*precise reasons*):
See supplemental sheet.

V. Substantiated Determination According to Article 35(2) with Respect to Novelty, Inventive Activity, and Industrial Applicability; Documents and Clarifications in Support of this Determination

1. DETERMINATION

Novelty	Claims 1,2,5,6,7,8,14,15	YES
	Claims	NO
Inventive	Claims 7,8,14,15	YES
Activity	Claims 1,2,5,6	NO
Industrial	Claims 1,2,5,6,7,8,14,15	YES
Applicability	Claims	NO

2. DOCUMENTS AND CLARIFICATIONS

See supplemental sheet.

VII. Specific Shortcomings of the International Application

It was determined that the International Application has the following shortcomings in form or content:

See supplemental sheet.

**PROVISIONAL INTERNATIONAL REPORT OF EXAMINATION
SUPPLEMENTAL SHEET**

Regarding Point III

No Provision of an Expert Report regarding Novelty, Inventive Activity, and Industrial Applicability

Claims 4, 9, 10, 11, 12, and 13 contain features (the connecting sleeve, the two bellows parts, and the roll-bellows halves) which are not defined in the Claims to which they refer back. Therefore, the subject matter of these Claims is unclear (Article 6 PCT).

Regarding Point V

Substantiated Determination According to Article 35(2) with Respect to Novelty, Inventive Activity, and Industrial Applicability; Documents and Clarifications in Support of this Determination

Document U.S. Patent A 4,493,481 (D1) represents the closest Prior Art.

It discloses:

a combined spring-and-shock-absorber system 1 (in particular, see column 2, lines 34 through 62 and the word "damping effects" in line 44) for supporting wheel suspensions or axles on a vehicle body using a tubular roll bellows 2 arranged between a wheel-bearing or wheel-controlling connection 18 and a connection on the vehicle-body side 17, the bellows being arranged between an outer bell 9 and a rolling piston 8, the outer bell and the rolling piston, in each case, over the height of the corresponding component, having at least partially varying diameters with respect to the walls that contact the tubular roll bellows, and both ends of the tubular roll bellows being sealingly secured on the rolling piston at segments having different diameters 13, 14, the lower mounting section 13 having a larger diameter than the upper mounting

section 14, and the bellows interior being filled with a fluid (in this case, air).

The subject matter of Claim 1 is distinguished from D1 by the fact that the bellows interior communicates with a hydraulic accumulator that is supported on the chassis and/or vehicle body side.

This differentiating feature, however, was already used for the purpose of regulating the spring performance and spring level in a similar device; in this regard, see document British Patent A 2,318,851 (D2). If the worker skilled in the art wishes to achieve the same purpose in a device according to the document D1, then it is possible for him without further difficulty to apply the features to the same effect. In this manner, he would, without any inventive addition, arrive at a device in accordance with Claim 1.

The subject matter of Claim 1 therefore does not rest on an inventive activity (Article 33(3) PCT).

Document D2, with respect to the features of Claims 2 and 5, describes the same advantages as the present application. The worker skilled in the art would therefore view the adoption of these features in the device described in D1 as a customary design measure.

The selection of a water-alcohol solution for the fluid in accordance with Claim 6 does not present any difficulty for the worker skilled in the art.

Claims 2, 5, and 6 do not fulfill the requirement of Article 33(3) PCT.

The features of Claim 7 are neither known nor suggested in the Prior Art.

Claim 7 fulfills the requirement of Article 33 (3) PCT.

The further features of Claim 8, with respect to document D1, where the volume enclosed by the differential roll bellows is connected in a controllable manner, via tubular connectors located in the wall of the outer bell, to an accumulator volume and to a pressure pump, are neither known nor suggested in the Prior Art.

The subject matter of Claim 8 is therefore to be seen as novel and inventive.

Claims 14 and 15 depend on Claim 8.

~~Therefore, Claims 8, 14, and 15 fulfill the requirements of~~
Article 33(2) and 33(3) PCT.

Regarding Point VII

Specific Shortcomings of the International Application

Claim 1, it is true, is prepared in the two-part form; however, the feature that the bellows interior is filled with a fluid is presented, incorrectly, in the characterizing part, since it was disclosed in document D1 in connection with the features cited in the preamble (Regulation 6.3 b) PCT).

Claim 8, it is true, is prepared in the two-part form; however, the feature that the bellows interior is filled with a fluid is presented, incorrectly, in the characterizing part, since it was disclosed in document D1 in connection with the features cited in the preamble (Regulation 6.3 b) PCT).

The features of the preamble of Claims 1 and 8 have not been provided with reference numerals set in parentheses (Regulation 6.2 b) PCT).

[10537/199]

SPRING-AND-SHOCK-ABSORBER SYSTEM HAVING DIFFERENTIAL ROLL
BELLOWS5 [Description] FIELD OF THE INVENTION

The present invention relates to a combined
spring-and-shock-absorber system for supporting wheel
suspensions or axles on a vehicle body using a tubular roll
bellows (U-bellows) arranged between a wheel-bearing or
10 wheel-controlling connection and a connection on the vehicle
body side, the bellows being arranged between an outer bell
and a rolling piston, the outer bell and the rolling piston,
in each case, having at least partially varying diameters over
the height of the corresponding component, and having [at
15 least partially varying diameters with respect to the] walls
that contact the tubular roll bellows[, and both]. Both ends
of the tubular roll bellows [being] are sealingly secured on
the rolling piston at segments having different diameters, the
lower mounting section having a larger diameter than the upper
20 mounting section.

BACKGROUND INFORMATION

United States Published Patent No. 4,518,154, describes a
conventional [From U.S. Patent 4,518,154, a] pneumatic
25 suspension system [of this type] for vehicles [is known]. The
outer bell and the multi-part rolling piston enclose a unitary
differential roll bellows. Due to the low gas pressure and the
use of a differential roll bellows, this design [requires] may
require an installation space of an excessively large volume.

30 In addition, [from] German Published Patent No. 297 02 927
[C1, a] describes a conventional spring-and-shock-absorber
system [is known], which is composed of a displacement device
without a bellows, a hydraulic accumulator, and a hydraulic
35 line connecting these parts. In the hydraulic line, a

mechanical choker valve is arranged. The displacement device, as is [familiar] conventional in a hydropneumatic suspension system, connects the vehicle wheel suspension to the vehicle body. The system is filled with a hydraulic fluid. The latter, when a vehicle wheel is spring deflected, is forced through the choker valve into a hydraulic accumulator. The flow resistance of the choker valve generates a damping force, whereas the compression of the gas volume in the hydraulic accumulator creates a spring force. In accordance with the principle of displacement presented here, a displacement piston plunges into a displacement cylinder. Both parts move in a guiding and sealing interaction, generating friction against each other. The friction impairs the response time of the spring-and-shock-absorber system, so that when it is used in a vehicle, the driving comfort of wheels supported by this system [is not optimal.] may not be optimal.

[From] United States Published Patent No. 4,493,481 depicts a pneumatic spring for motor vehicles having a closed spring volume and two effective, changeable spring surfaces, whose sizes are a function of the spring elongation, and which are supported in a coaxial manner against each other, the spring surfaces being of different sizes, mutually acted upon by pressure, and facing away from each other. The tubular roll bellows is secured on both ends, having the same diameters, on the rolling piston and is configured as a one-piece tubular roll bellows.

In British Published Patent No. 2,318,851, a multi-bellows spring system having hydraulic accumulators connected by lines is described. Two separate, enclosed bellows, that are different in size, have each available to it its own hydraulic accumulator. These are two systems that are separated from each other hydraulically, each bellows, viewed in the spring direction, on the chassis side and on the wheel-controlling

side, having the same piston surfaces. The bellows are essentially freestanding bellows, whereas in the exemplary embodiments according to the invention, the bellows are supported over virtually the entire area between an outer bell
5 and a rolling piston. Between the bellows, there is a mechanical transmission element that is independent of the bellows.

10 As described in numerous publications and from practice, conventional diverse motor vehicle air suspension systems are [known. They are] essentially composed of a roll bellows that encloses a volume of air and that is bordered on its one end
15 by a chassis-fixed covering plate and on its other end by a wheel-side rolling piston. Conventional air spring systems of this type [have no] may lack stability with regard to tilting, so that additional measures [are] may be required for the longitudinal and transverse guiding functions.

20 SUMMARY OF THE INVENTION

The present invention [is based on the problem] concerns the development of [developing] a combined spring-and-shock-absorber system, which contains a low-friction, thin-design displacement device that is based on
25 a tubular roll bellows and that has great transverse rigidity. In addition, [the] an objective of the present invention [can be seen in] may include creating a suspension device that is acted upon by a pressure medium, the device being controllable with regard to suspension performance and the height of the
30 spring, and it being such that it is completely or at least substantially possible to do without external longitudinal and transverse suspension links.

[The problem is solved by the features of the main claim. For
35 this purpose] According to one exemplary embodiment and/or

exemplary method of the present invention, a tubular roll bellows [is] may be used, which [is] may be configured as a differential roll bellows, whose interior [is] may be filled with a fluid and [communicates] may communicate to a hydraulic accumulator that is supported on the chassis or on the vehicle side.

The type of displacement bellows, the type of connection on the chassis and on the vehicle body, and the [fact] possibility that the bellows interior [is] may be filled with a fluid that is prestressed using a gas make possible a slim displacement device that does not have a mechanical, friction-producing longitudinal guide element. A separate longitudinal guide element [is] may be superfluous because the pressure in the displacement bellows, as a result of the two bellows meniscuses, centers and stabilizes the shock-absorber leg parts, which move relative to each other.

In response to a pressurizing or depressurizing of the displacement device, a hydraulic fluid flows back and forth between the displacement device and the hydraulic accumulator via a narrowing of the cross-section in the form of a hydraulic line or an opening. The configuration of the line, or the opening, and the characteristics of the restrictors arranged there influence the system dampening in accordance with the size and shape of the opening cross-section. In this context, the individual restrictor [can] may be configured either as a nozzle or an aperture, or at least as a one-way restrictor. When one-way restrictors are used, at least one valve for each flow direction [is] may be arranged in the cross-section of the line, or the opening.

The gas cushion of the hydraulic accumulator normally constitutes the suspension system.

As a result of using a tubular roll bellows in the form of a

differential roll bellows, the mechanical friction of the entire system [is] may be essentially reduced to the interior friction of the bellows or membrane material. As a result, the spring-and-shock-absorber system [demonstrates] may

5 demonstrate virtually ideal responsiveness over the entire range of damping rates. The outer bell and/or the rolling piston [can] may each be directly secured--even without the interposition of rubber-elastic elements--on the vehicle body, or on the chassis, via flexible couplings. This [reduces] may
10 reduce, inter alia, the component weight, the manufacturing costs, the difficulty of assembly, and maintenance costs.

Both rolling piston halves, in addition to the two corresponding halves of the differential roll bellows in the

15 suspension device according to the present invention, provide a self-centering guide function between the double rolling piston and the outer bell. On account of the relatively high operating pressure -- in comparison to conventional air suspension systems -- this radial guidance [is] may be
20 especially stable.

On the other hand, due to the rubber-elastic decoupling of piston and outer bell, the excitation of higher-frequency vibrations [is] may be filtered out. The shape of the
25 suspension device as a differential roll bellows [is] may be oblong, which, in addition to the very good radial (lateral) guidance, also provides very good longitudinal guidance. For this reason, it is possible, substantially or even entirely, to dispense with a separate longitudinal and transverse
30 control arm.

The spring force is determined by the difference in the effective radii of curvature of the two roll bellows halves (differential roll bellows halves). The radii of curvature of
35 the roll bellows halves are produced by the differences in the

radii (or diameters) of the outer bell and the two piston (halves). If the difference between the individual piston radii is slight, then the difference in the radii of curvature of the roll bellows halves [will] may also be slight. This has the consequence that it is possible to operate at a high operating pressure, as [is] may be required in active chassis control systems.

The difference in the effective roll-bellows radii of curvature, instead of using a difference in the piston radii, [can] may be realized using a radius difference of the effective outer-bell segments.

The roll bellows halves, arranged so as to be opposite each other, are clamped, on one side, to the outer bell and, on the other side, to the piston using clamping rings so as to be fixed in a mechanically reliable fashion and tight in the pneumatic/hydraulic sense.

The filling of the spring and the control system, specifically setting the spring level, but also controlling the rolling motion, [can] may be carried out using a controlled pressure pump, which [can] may be connected to the tubular connectors located on the outer bell. In addition, an accumulator volume [can] may also be connected.

For receiving a shock absorber, the piston [is preferably] may be configured so as to be a hollow cylinder. In this manner, it is possible to do without a separately arranged shock absorber. This [saves] may save both additional installation space as well as additional assembly work. The shock absorber, surrounded by the spring sleeve, [is] may be protected from road impurities.

The spring volume of the roll bellows halves [can] may

alternatively be filled with a compressed gas
[(preferably) (such as, for example, air) or with a hydraulic
fluid.

5 [Further details of the present invention can be found in the
subclaims and in the description below of two schematically
depicted exemplary embodiments:] BRIEF DESCRIPTION OF THE
DRAWINGS

[Figure 1:] Figure 1 shows a spring-and-shock-absorber system
10 having a differential roll bellows and an external hydraulic
accumulator[;].

Figure 2 [:] shows a spring-and-shock-absorber system having
an integrated hydraulic accumulator[;].

15 Figure 3 [:] shows a spring-and-shock-absorber system having a
compressible gas [(preferably) (such as, for example, air) or
hydraulic filling.

20 DETAILED DESCRIPTION

Figures 1 and 2 each depict a combined
spring-and-shock-absorber system, which includes a
displacement device (10), a hydraulic accumulator (70, 44,
62), and a fluid-containing working line (76), arranged
25 between the latter and having an integrated choker valve (77,
48, 64).

The displacement device (10) is composed, inter alia, of a
multi-stage outer bell (30), an also multi-stage rolling
30 piston (50), and a multi-part differential roll bellows (11),
connecting both elements. In response to a spring deflection
and rebound, rolling piston (50), secured, for example, on the
chassis, moves up and down, centeringly guided by differential
roll bellows (11). In this context, exterior wall (23, 24) of
35 differential roll bellows (11) rolls on outer bell (30) and on

rolling piston (50).

Outer bell (30) is a hollow body, which contains here two at least partially cylindrical segments (31, 33), which are connected to each other by a transition piece (32) in the shape of a truncated-cone sleeve. In Figure 1, segments (31, 32) and transition piece (33) are made of one part. Upper segment (31) is closed at its upper end by a plate (34). On plate (34), an adapter (35) is formed for the articulated connection to the vehicle body. The interior diameter of the upper, cylindrical segment (31) is, for example, one third smaller than the interior diameter of lower, cylindrical segment (33).

Segments (31) and (33) [can] may also have an interior contour in the shape of a truncated cone. In a case of this type, upper segment (31) would taper towards the top and lower segment (33) would taper towards the bottom.

Rolling piston (50) also has an upper (51) and a lower segment (55), both segments (51, 55) having, for example, a cylindrical outer shape (56, 57). The exterior diameter of upper segment (51) is smaller than the exterior diameter of segment (55). The exterior diameter of segment (51) is, for example, roughly 60% of the interior diameter of outer-bell segment (31). The diameter differential in the exemplary embodiment is selected so that, in each case, the gap between segments (31) and (51), opposite each other, is roughly the same width in the zones in which meniscuses (21, 22) of differential roll bellows (11) move.

In Figure 1, lower segment (55) of rolling piston (50) is tapered. The tapering begins below the zone which [can] may be contacted by differential roll bellows (11). The lower end of rolling piston (50) ends in an adapter (69) for the articulated connection to chassis (9).

Differential roll bellows (11), arranged between rolling piston (50) and outer bell (30), is composed, inter alia, of two potentially identical tubular roll-bellows halves (12, 13). Roll bellows halves (12, 13) are oriented in a coaxial manner with respect to each other and are mounted on each other in a gas- and fluid-tight manner via a roughly tubular connecting sleeve (14). Connecting sleeve (14) is a short tube, onto which from both sides a roll-bellows half (12, 13) is slid. Each attached segment of corresponding roll-bellows halves (12, 13) is fixed in a non-skid manner on connecting sleeve (14) using a clamping ring (17, 18), for example, in a force- and form-locking manner. In Figures 1 and 2, the connecting sleeve between clamping rings (17, 18) has a tubular segment (15), which is not covered by roll-bellows halves (12, 13). This tubular segment (15) has an exterior diameter which is only slightly smaller than the interior diameter of lower segment (33) of outer bell (30).

To secure differential roll bellows (11) on rolling piston (50), the lower end of differential roll bellows (11), which is open at the tube ends, is slid on interior wall (26) onto the upper end of lower rolling piston segment (55) and is clamped securely using a clamping ring (59). Segment (55) has there a radius that is reduced by the sum of the wall thicknesses of clamping ring (58) and of bellows (11).

In a second step, rolling piston (50) is inserted into differential roll bellows (11), until the upper roll-bellows end reaches the middle of upper segment (51). During the insertion, the lower area of roll bellows (11) is turned back over clamping ring (59), so that exterior wall (24) of bellows (11) contacts rolling-piston segment (55).

In the center of upper segment (51) is located a recess (53), in which interior wall (25) of the upper end of bellows (11) is fixed using a clamping ring (58). The depth of recess (53)

is chosen so that the exterior contour of mounted clamping ring (58) has approximately the same diameter as segment (51) in the zone, which, in the assembled state, exterior wall (24) of bellows (11) contacts. Beneath recess (53), in the exemplary embodiments, segment (51) has a diameter which is greater by roughly double the bellows wall thickness in comparison with the diameter of segment (51) above recess (53).

After the mounting of differential roll bellows (11) on rolling piston (50), both parts are inserted into outer bell (30), until connecting sleeve (14), having roll bellows half (12), contacts transition piece (32). For the final positioning of differential roll bellows (11), rolling piston

(50) is pulled back into a central position within outer bell (30). In this context, as a meniscus (21) is formed having an upwards orientation, exterior wall (23) of roll bellows half (12) is turned back over clamping ring (58) and outer wall (56) of segment (51).

Consequently, in response to every operationally-caused relative motion between parts (30) and (50), exterior walls (23, 24) of differential roll bellows (11) roll on outer walls (56, 57) and inner walls (36, 37). Because in the exemplary embodiments, menisci (21, 22) of differential roll bellows (11) move in narrow annular spaces having cylindrical walls, the centering forces and the transverse rigidity are virtually constant over the entire stroke of the spring-and-shock-absorber leg.

Therefore, menisci (21, 22) in the entire stroke range move between rolling piston (50) and outer bell (30) in, for example, cylindrical zones. In this context, meniscus (21) realizes a piston surface, which is, for example, two-thirds smaller than the active piston surface on segment (55).

According to Figure 1, the usable overall stroke of the shock absorber leg corresponds to roughly the interior diameter of outer bell (30) in the area of segment (33).

- 5 The lengths of individual roll-bellows halves (12) and (13) correspond, for example, to one-and-a-half to double the bellows diameter in the area of the segment (33).

10 Interior (5), enclosed by differential roll bellows (11), is filled with an incompressible fluid (1), which, according to Figure 1, is under pressure by a gas cushion enclosed in a hydraulic accumulator (70). Hydraulic accumulator (70) is configured, for example, as a bubble or membrane accumulator. Gas cushion (72), divided by the bladder or membrane,
15 constitutes the suspension unit of the spring-and-shock-absorber system.

Hydraulic accumulator (70), which is depicted in an arrangement next to outer bell (30) only by way of example, is
20 connected to bellows interior (5) via a working line (76). For this purpose, working line (76) runs through outer-bell segment (33) and connects to connecting sleeve (14). In this way, working line (76) itself positions connecting sleeve (14) in outer-bell segment (33) in a form-locking manner.

25 In housing (74) of hydraulic accumulator (70), on the transition to working line (76), are located two operating pressure-stage valves, opposite each other, in the form of spring-plate valves (77). Each valve (77) opens in one flow
30 direction. In this context, the choking effect of the individual throttle return valve (77) [can] may be carried out so as to be adjustable, if necessary, using a drive that [can] may be controlled or regulated.

35 If appropriate, a blockable supply line [can] may be connected to working line (76). Assuming use as an active

spring-and-shock-absorber system, or as a level regulator, fluid would be supplied or removed from the displacement device via a supply line of this type.

5 By supplying and removing a predetermined quantity of fluid, additional forces [can] may be realized in an appropriate manner. The supplying or removal of these additional quantities changes the damping and the spring forces in the entire system.

10

Fluid (1), used in the spring-and-shock-absorber system, is, for example, a solution of water and alcohol. For this solution, all alcohols are appropriate which [can] may be mixed at room temperature in any ratio with water. For

15 example, a water-ethanol solution or a water-glycol solution [is] may be used. A conventional water-glycol solution, which is also used as an anti-freeze coolant in internal combustion engines, [has] may have, for example, an ethylene glycol component of 33 to 50%. Using a 50-percent solution, it [is]
20 may be possible to operate the spring-and-shock-absorber system down to a temperature of -35° Celsius. In addition, this solution [does] may not corrode the usual elastomer materials. Furthermore, the rubber expansion is in the order of magnitude of the expansion in pure water.

25

Figure 2 depicts a spring-and-shock-absorber system having two hydraulic accumulators, which are integrated in a space-saving manner. For this purpose, at least lower segment (55) of rolling piston (50) is configured as a hollow body, or a
30 stepped blind-hole bore (61), having at least two hollow spaces (62) and (65), which are separated from each other. The hollow spaces, for this purpose, are arranged, for example, so as to be coaxial with respect to each other.

35 Exterior hollow space (65) is an annular space, which is formed by the interior wall of rolling piston (50) and a

foliated tubular membrane (66). Tubular membrane (66), for this purpose, is fixed at the upper end by a ring adapter (67) in the area of the base of blind-hole bore (61) and at its lower end by a comparable ring adapter (67) in a base plate
5 screwed into rolling piston (50). Annular space (65) is filled with gas via a valve (68) that is situated in this base plate.

Central hollow space (62) is in a hydraulic connection to bellows interior (5) via bore holes (63) and a double-acting
10 leaf valve (64).

The second hydraulic accumulator is arranged in the area of upper outer-bell segment (31). For this purpose, outer bell (30) is surrounded here by, for example, a tubular housing
15 (41). Between this housing (41) and the exterior contour of outer bell (30) is situated a general annular space, which is divided by a tubular membrane (42) into an inner (43) and outer annular space (44). Inner annular space (43) is filled with gas, see valve (45), whereas exterior annular space (44),
20 comparable to fluid space (75) in Figure 1, communicates with bellows interior (5) via at least one leaf valve (48). Leaf valve(s) (48) in the exemplary embodiments according to Figure 2 are situated in a detachable housing (46). Interior space (47) of housing (46) is connected to bellows interior (5) via
25 working line (76).

If appropriate, spaces (44) and (62) [can] may also be hydraulically connected to each other directly and only communicate with bellows interior (5) via a double-acting leaf
30 valve.

In contrast to Figure 1, a rubber damping element (49), as an elastic limit stop, is located in deaerated return space (7). In addition, upper segment (51) of rolling piston (50) is
35 furnished with a closed bore hole (52) to reduce the unsuspended mass.

Between the chassis and the vehicle body, the spring leg [can] may also be arranged so as to have an outer bell attached in an articulated manner to the chassis. For this purpose, at least the contours of the rolling piston and the outer bell [must] may be required to be adjusted to the new orientation of the rebound spring direction.

As an alternative to the exemplary embodiments described above, a spring-and-shock-absorber system is conceivable in which fluid (1) used in the system is a magneto-rheological fluid. If on hydraulic working line (76), for example, a short annular segment is surrounded by a current-excited solenoid coil, then the excited solenoid coil in combination with fluid (1) represents a variable restrictor. As the current supplied to the coil increases, the flow velocity decreases as a result of an increase in the apparent or dynamic viscosity in working line (76), as a result of which, inter alia, the damping performance of the entire system [can] may be changed in a controlled manner.

Suspension device (2) depicted in Figure 3 is composed of an outer bell (30), which is configured in a cylindrical manner, and an interior piston (50). Piston (50), arranged so as to be co-axial with respect to outer bell (30), is configured as a double rolling piston. First (upper) partial piston (51) of double rolling piston (50) has exterior diameter (D_a), whereas second (lower) partial piston (55) has exterior diameter (D_b). Piston (50) made up of partial pistons (51) and (55), is axially movable within outer bell (30) having interior diameter (D_1).

Inside widths ($D_1 - D_a$) and ($D_1 - D_b$) between partial pistons (51) and (55) and outer bell (30) are filled by two roll-bellows halves (12) and (13), arranged opposite each other. Roll-bellows halves (12, 13) form a differential roll bellows (11) and are made of an elastomer material that is

reinforced by a fabric insert. A (first) roll bellows (12) is assigned to one partial piston (51), whereas other (second) roll bellows (13) surrounds other partial piston (55). The ends of roll-bellows halves (12, 13) are clamped, on one side, on piston (50) using clamping rings (58, 59), and, on the other side, on outer bell (30) using an exterior ring (14) next to clamping rings (17, 18) in a pressure-tight manner. The exterior ring has two tubular connectors (76, 82) for connecting to a pump and to an accumulator (not depicted); the suspension device (2) [can] may be controlled by tubular connectors (76, 82).

Piston (50), depicted in the drawing, is configured in a hollow cylindrical manner. Its interior contains a shock

absorber (80), whose tube is secured on the upper piston end by a spring ring (90). The sealing tightness between shock absorber (tube) (80) and piston (50) is realized by three O-rings (92, 94, 96). Shock-absorber rod (81) is mounted on a covering plate (86) located on outer bell (30).

If piston (50), mounted on the wheel side, moves axially in relation to chassis-side outer bell (30), then both roll-bellows halves (12, 13), located between piston (50) and outer bell (30), roll, on one side, on the exterior surface of piston (50) and, on the other side, on the interior surface of outer bell (30). The axial force resulting from the application of pressure to roll-bellows halves (12, 13) using compressed air or hydraulic fluid, is proportional to the difference between the effective roll-bellows radii of curvature.

List of Reference Numerals

	1	fluid, water-glycol solution
	2	suspension device
5	5	bellows interior
	7	return space
	9	chassis
	10	displacement device
10	11	tubular roll bellows, differential roll bellows, bellows
	12,13	roll bellows halves, bellows parts
	14	connecting sleeve
	15	tubular segment
15	17,18	clamping rings
	21,22	meniscuses
	23,24	outer walls
	25,26	inner walls
20	30	outer bell
	31	upper segment
	32	transitional piece
	33	lower segment
25	34	base
	35	adapter
	36,37	interior walls
	41	housing, tubular
30	42	membrane, hose-like
	43	interior annular space
	44	exterior annular space
	45	valve
	46	detachable housing
35	47	housing interior space
	48	leaf valve

	49	rubber damping element
	50	rolling piston, piston
	51	upper segment
5	52	bore
	53	recess
	55	lower segment
	56,57	exterior walls
	58,59	clamping rings
10		
	61	blind-hole bore
	62	interior hollow space, central
	63	bores
	64	leaf valve
15	65	exterior hollow space, annular space
	66	tubular membrane
	67	ring adapter
	68	valve
	69	adapter, adapter having articulated joint
20		
	70	hydraulic accumulator
	71	membrane
	72	gas cushion
	74	housing
25	75	fluid space
	76	working line, tubular connector
	77	choker valves, pressure stage valves
30	80	shock absorber
	81	shock absorber rod
	82	tubular connector, pump connection
	86	cover, sleeve cylinder
	88	extension of shock absorber tube
35	90	spring ring
	92,94,96	O-ring

D1 interior diameter outer bell
Da exterior diameter first piston
Db exterior diameter second piston

[Abstract] ABSTRACT

[The present invention relates to a] A combined
5 spring-and-shock-absorber system for supporting wheel
suspensions or axles on a vehicle body [using] has a tubular
roll bellows (U-bellows) arranged between a wheel-bearing or
wheel-controlling connection and a connection on the vehicle
body side, the bellows being arranged between an outer bell
10 and a rolling piston, the outer bell and the rolling piston,
in each case, having at least partially varying diameters over
the height of the corresponding component, and having [at
least partially varying diameters with respect to the] walls
that contact the tubular roll bellows[, and both]. Both ends
15 of the tubular roll bellows being sealingly secured on the
rolling piston at segments having different diameters, the
lower mounting section having a larger diameter than the upper
mounting section. For this purpose, a tubular roll bellows is
used, which is configured as a differential roll bellows,
20 whose interior is filled with a fluid and communicates with a
hydraulic accumulator supported on the chassis and/or vehicle
body.

On the basis of the present invention, a combined
25 spring-and-shock-absorber system is developed, which contains
a friction-free displacement device in a thin construction.

SPRING-AND-SHOCK-ABSORBER SYSTEM HAVING DIFFERENTIAL ROLL
BELLOWS

5 FIELD OF THE INVENTION

The present invention relates to a combined spring-and-shock-absorber system for supporting wheel suspensions or axles on a vehicle body using a tubular roll bellows (U-bellows) arranged between a wheel-bearing or wheel-controlling connection and a connection on the vehicle body side, the bellows being arranged between an outer bell and a rolling piston, the outer bell and the rolling piston, in each case, having at least partially varying diameters over the height of the corresponding component, and having walls that contact the tubular roll bellows. Both ends of the tubular roll bellows are sealingly secured on the rolling piston at segments having different diameters, the lower mounting section having a larger diameter than the upper mounting section.

20 BACKGROUND INFORMATION

United States Published Patent No. 4,518,154, describes a conventional pneumatic suspension system for vehicles. The outer bell and the multi-part rolling piston enclose a unitary differential roll bellows. Due to the low gas pressure and the use of a differential roll bellows, this design may require an installation space of an excessively large volume.

In addition, German Published Patent No. 297 02 927 describes a conventional spring-and-shock-absorber system, which is composed of a displacement device without a bellows, a hydraulic accumulator, and a hydraulic line connecting these parts. In the hydraulic line, a mechanical choker valve is arranged. The displacement device, as is conventional in a hydropneumatic suspension system, connects the vehicle wheel suspension to the vehicle body. The system is filled with a hydraulic fluid. The latter, when a vehicle wheel is spring

deflected, is forced through the choker valve into a hydraulic accumulator. The flow resistance of the choker valve generates a damping force, whereas the compression of the gas volume in the hydraulic accumulator creates a spring force. In accordance with the principle of displacement presented here, a displacement piston plunges into a displacement cylinder. Both parts move in a guiding and sealing interaction, generating friction against each other. The friction impairs the response time of the spring-and-shock-absorber system, so that when it is used in a vehicle, the driving comfort of wheels supported by this system may not be optimal.

United States Published Patent No. 4,493,481 depicts a pneumatic spring for motor vehicles having a closed spring volume and two effective, changeable spring surfaces, whose sizes are a function of the spring elongation, and which are supported in a coaxial manner against each other, the spring surfaces being of different sizes, mutually acted upon by pressure, and facing away from each other. The tubular roll bellows is secured on both ends, having the same diameters, on the rolling piston and is configured as a one-piece tubular roll bellows.

In British Published Patent No. 2,318,851, a multi-bellows spring system having hydraulic accumulators connected by lines is described. Two separate, enclosed bellows, that are different in size, have each available to it its own hydraulic accumulator. These are two systems that are separated from each other hydraulically, each bellows, viewed in the spring direction, on the chassis side and on the wheel-controlling side, having the same piston surfaces. The bellows are essentially freestanding bellows, whereas in the exemplary embodiments according to the invention, the bellows are supported over virtually the entire area between an outer bell and a rolling piston. Between the bellows, there is a mechanical transmission element that is independent of the bellows.

As described in numerous publications and from practice, conventional diverse motor vehicle air suspension systems are essentially composed of a roll bellows that encloses a volume of air and that is bordered on its one end by a chassis-fixed covering plate and on its other end by a wheel-side rolling piston. Conventional air spring systems of this type may lack stability with regard to tilting, so that additional measures may be required for the longitudinal and transverse guiding functions.

SUMMARY OF THE INVENTION

The present invention concerns the development of a combined spring-and-shock-absorber system, which contains a low-friction, thin-design displacement device that is based on a tubular roll bellows and that has great transverse rigidity. In addition, an objective of the present invention may include creating a suspension device that is acted upon by a pressure medium, the device being controllable with regard to suspension performance and the height of the spring, and it being such that it is completely or at least substantially possible to do without external longitudinal and transverse suspension links.

According to one exemplary embodiment and/or exemplary method of the present invention, a tubular roll bellows may be used, which may be configured as a differential roll bellows, whose interior may be filled with a fluid and may communicate to a hydraulic accumulator that is supported on the chassis or on the vehicle side.

The type of displacement bellows, the type of connection on the chassis and on the vehicle body, and the possibility that the bellows interior may be filled with a fluid that is prestressed using a gas make possible a slim displacement device that does not have a mechanical, friction-producing

longitudinal guide element. A separate longitudinal guide element may be superfluous because the pressure in the displacement bellows, as a result of the two bellows meniscuses, centers and stabilizes the shock-absorber leg parts, which move relative to each other.

In response to a pressurizing or depressurizing of the displacement device, a hydraulic fluid flows back and forth between the displacement device and the hydraulic accumulator via a narrowing of the cross-section in the form of a hydraulic line or an opening. The configuration of the line, or the opening, and the characteristics of the restrictors arranged there influence the system dampening in accordance with the size and shape of the opening cross-section. In this context, the individual restrictor may be configured either as a nozzle or an aperture, or at least as a one-way restrictor. When one-way restrictors are used, at least one valve for each flow direction may be arranged in the cross-section of the line, or the opening.

The gas cushion of the hydraulic accumulator normally constitutes the suspension system.

As a result of using a tubular roll bellows in the form of a differential roll bellows, the mechanical friction of the entire system may be essentially reduced to the interior friction of the bellows or membrane material. As a result, the spring-and-shock-absorber system may demonstrate virtually ideal responsiveness over the entire range of damping rates.

The outer bell and/or the rolling piston may each be directly secured--even without the interposition of rubber-elastic elements--on the vehicle body, or on the chassis, via flexible couplings. This may reduce, inter alia, the component weight, the manufacturing costs, the difficulty of assembly, and maintenance costs.

Both rolling piston halves, in addition to the two

corresponding halves of the differential roll bellows in the suspension device according to the present invention, provide a self-centering guide function between the double rolling piston and the outer bell. On account of the relatively high operating pressure -- in comparison to conventional air suspension systems -- this radial guidance may be especially stable.

On the other hand, due to the rubber-elastic decoupling of piston and outer bell, the excitation of higher-frequency vibrations may be filtered out. The shape of the suspension device as a differential roll bellows may be oblong, which, in addition to the very good radial (lateral) guidance, also provides very good longitudinal guidance. For this reason, it is possible, substantially or even entirely, to dispense with a separate longitudinal and transverse control arm.

The spring force is determined by the difference in the effective radii of curvature of the two roll bellows halves (differential roll bellows halves). The radii of curvature of the roll bellows halves are produced by the differences in the radii (or diameters) of the outer bell and the two piston (halves). If the difference between the individual piston radii is slight, then the difference in the radii of curvature of the roll bellows halves may also be slight. This has the consequence that it is possible to operate at a high operating pressure, as may be required in active chassis control systems.

The difference in the effective roll-bellows radii of curvature, instead of using a difference in the piston radii, may be realized using a radius difference of the effective outer-bell segments.

The roll bellows halves, arranged so as to be opposite each other, are clamped, on one side, to the outer bell and, on the other side, to the piston using clamping rings so as to be

fixed in a mechanically reliable fashion and tight in the pneumatic/hydraulic sense.

5 The filling of the spring and the control system, specifically setting the spring level, but also controlling the rolling motion, may be carried out using a controlled pressure pump, which may be connected to the tubular connectors located on the outer bell. In addition, an accumulator volume may also be connected.

10 For receiving a shock absorber, the piston may be configured so as to be a hollow cylinder. In this manner, it is possible to do without a separately arranged shock absorber. This may save both additional installation space as well as additional
15 assembly work. The shock absorber, surrounded by the spring sleeve, may be protected from road impurities.

The spring volume of the roll bellows halves may alternatively be filled with a compressed gas (such as, for example, air) or
20 with a hydraulic fluid.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a spring-and-shock-absorber system having a differential roll bellows and an external hydraulic
25 accumulator.

Figure 2 shows a spring-and-shock-absorber system having an integrated hydraulic accumulator.

30 Figure 3 shows a spring-and-shock-absorber system having a compressible gas (such as, for example, air) or hydraulic filling.

DETAILED DESCRIPTION

35 Figures 1 and 2 each depict a combined spring-and-shock-absorber system, which includes a displacement device (10), a hydraulic accumulator (70, 44, 62), and a fluid-containing

working line (76), arranged between the latter and having an integrated choker valve (77, 48, 64).

5 The displacement device (10) is composed, inter alia, of a multi-stage outer bell (30), an also multi-stage rolling piston (50), and a multi-part differential roll bellows (11), connecting both elements. In response to a spring deflection and rebound, rolling piston (50), secured, for example, on the chassis, moves up and down, centeringly guided by differential
10 roll bellows (11). In this context, exterior wall (23, 24) of differential roll bellows (11) rolls on outer bell (30) and on rolling piston (50).

15 Outer bell (30) is a hollow body, which contains here two at least partially cylindrical segments (31, 33), which are connected to each other by a transition piece (32) in the shape of a truncated-cone sleeve. In Figure 1, segments (31, 32) and transition piece (33) are made of one part. Upper segment (31) is closed at its upper end by a plate (34). On
20 plate (34), an adapter (35) is formed for the articulated connection to the vehicle body. The interior diameter of the upper, cylindrical segment (31) is, for example, one third smaller than the interior diameter of lower, cylindrical segment (33).

25 Segments (31) and (33) may also have an interior contour in the shape of a truncated cone. In a case of this type, upper segment (31) would taper towards the top and lower segment (33) would taper towards the bottom.

30 Rolling piston (50) also has an upper (51) and a lower segment (55), both segments (51, 55) having, for example, a cylindrical outer shape (56, 57). The exterior diameter of upper segment (51) is smaller than the exterior diameter of
35 segment (55). The exterior diameter of segment (51) is, for example, roughly 60% of the interior diameter of outer-bell segment (31). The diameter differential in the exemplary

embodiment is selected so that, in each case, the gap between segments (31) and (51), opposite each other, is roughly the same width in the zones in which meniscuses (21, 22) of differential roll bellows (11) move.

5

In Figure 1, lower segment (55) of rolling piston (50) is tapered. The tapering begins below the zone which may be contacted by differential roll bellows (11). The lower end of rolling piston (50) ends in an adapter (69) for the articulated connection to chassis (9).

10

Differential roll bellows (11), arranged between rolling piston (50) and outer bell (30), is composed, inter alia, of two potentially identical tubular roll-bellows halves (12,

15 13). Roll bellows halves (12, 13) are oriented in a coaxial manner with respect to each other and are mounted on each other in a gas- and fluid-tight manner via a roughly tubular connecting sleeve (14). Connecting sleeve (14) is a short tube, onto which from both sides a roll-bellows half (12, 13)
20 is slid. Each attached segment of corresponding roll-bellows halves (12, 13) is fixed in a non-skid manner on connecting sleeve (14) using a clamping ring (17, 18), for example, in a force- and form-locking manner. In Figures 1 and 2, the connecting sleeve between clamping rings (17, 18) has a
25 tubular segment (15), which is not covered by roll-bellows halves (12, 13). This tubular segment (15) has an exterior diameter which is only slightly smaller than the interior diameter of lower segment (33) of outer bell (30).

30 To secure differential roll bellows (11) on rolling piston (50), the lower end of differential roll bellows (11), which is open at the tube ends, is slid on interior wall (26) onto the upper end of lower rolling piston segment (55) and is clamped securely using a clamping ring (59). Segment (55) has
35 there a radius that is reduced by the sum of the wall thicknesses of clamping ring (58) and of bellows (11).

In a second step, rolling piston (50) is inserted into differential roll bellows (11), until the upper roll-bellows end reaches the middle of upper segment (51). During the insertion, the lower area of roll bellows (11) is turned back over clamping ring (59), so that exterior wall (24) of bellows (11) contacts rolling-piston segment (55).

In the center of upper segment (51) is located a recess (53), in which interior wall (25) of the upper end of bellows (11) is fixed using a clamping ring (58). The depth of recess (53) is chosen so that the exterior contour of mounted clamping ring (58) has approximately the same diameter as segment (51) in the zone, which, in the assembled state, exterior wall (24) of bellows (11) contacts. Beneath recess (53), in the exemplary embodiments, segment (51) has a diameter which is greater by roughly double the bellows wall thickness in comparison with the diameter of segment (51) above recess (53).

After the mounting of differential roll bellows (11) on rolling piston (50), both parts are inserted into outer bell (30), until connecting sleeve (14), having roll bellows half (12), contacts transition piece (32). For the final positioning of differential roll bellows (11), rolling piston (50) is pulled back into a central position within outer bell (30). In this context, as a meniscus (21) is formed having an upwards orientation, exterior wall (23) of roll bellows half (12) is turned back over clamping ring (58) and outer wall (56) of segment (51).

Consequently, in response to every operationally-caused relative motion between parts (30) and (50), exterior walls (23, 24) of differential roll bellows (11) roll on outer walls (56, 57) and inner walls (36, 37). Because in the exemplary embodiments, menisci (21, 22) of differential roll bellows (11) move in narrow annular spaces having cylindrical walls, the centering forces and the transverse rigidity are virtually

constant over the entire stroke of the spring-and-shock-absorber leg.

Therefore, meniscuses (21, 22) in the entire stroke range move
5 between rolling piston (50) and outer bell (30) in, for example, cylindrical zones. In this context, meniscus (21) realizes a piston surface, which is, for example, two-thirds smaller than the active piston surface on segment (55).

10 According to Figure 1, the usable overall stroke of the shock absorber leg corresponds to roughly the interior diameter of outer bell (30) in the area of segment (33).

The lengths of individual roll-bellows halves (12) and (13)
15 ~~correspond, for example, to one-and-a-half to double the~~
bellows diameter in the area of the segment (33).

Interior (5), enclosed by differential roll bellows (11), is filled with an incompressible fluid (1), which, according to
20 Figure 1, is under pressure by a gas cushion enclosed in a hydraulic accumulator (70). Hydraulic accumulator (70) is configured, for example, as a bubble or membrane accumulator. Gas cushion (72), divided by the bladder or membrane, constitutes the suspension unit of the spring-and-shock-
25 absorber system.

Hydraulic accumulator (70), which is depicted in an arrangement next to outer bell (30) only by way of example, is connected to bellows interior (5) via a working line (76). For
30 this purpose, working line (76) runs through outer-bell segment (33) and connects to connecting sleeve (14). In this way, working line (76) itself positions connecting sleeve (14) in outer-bell segment (33) in a form-locking manner.

35 In housing (74) of hydraulic accumulator (70), on the transition to working line (76), are located two operating pressure-stage valves, opposite each other, in the form of

spring-plate valves (77). Each valve (77) opens in one flow direction. In this context, the choking effect of the individual throttle return valve (77) may be carried out so as to be adjustable, if necessary, using a drive that may be controlled or regulated.

If appropriate, a blockable supply line may be connected to working line (76). Assuming use as an active spring-and-shock-absorber system, or as a level regulator, fluid would be supplied or removed from the displacement device via a supply line of this type.

By supplying and removing a predetermined quantity of fluid, additional forces may be realized in an appropriate manner.

~~15~~ The supplying or removal of these additional quantities changes the damping and the spring forces in the entire system.

Fluid (1), used in the spring-and-shock-absorber system, is, for example, a solution of water and alcohol. For this solution, all alcohols are appropriate which may be mixed at room temperature in any ratio with water. For example, a water-ethanol solution or a water-glycol solution may be used. A conventional water-glycol solution, which is also used as an anti-freeze coolant in internal combustion engines, may have, for example, an ethylene glycol component of 33 to 50%. Using a 50-percent solution, it may be possible to operate the spring-and-shock-absorber system down to a temperature of -35° Celsius. In addition, this solution may not corrode the usual elastomer materials. Furthermore, the rubber expansion is in the order of magnitude of the expansion in pure water.

Figure 2 depicts a spring-and-shock-absorber system having two hydraulic accumulators, which are integrated in a space-saving manner. For this purpose, at least lower segment (55) of rolling piston (50) is configured as a hollow body, or a stepped blind-hole bore (61), having at least two hollow

spaces (62) and (65), which are separated from each other. The hollow spaces, for this purpose, are arranged, for example, so as to be coaxial with respect to each other.

5 Exterior hollow space (65) is an annular space, which is formed by the interior wall of rolling piston (50) and a foliated tubular membrane (66). Tubular membrane (66), for this purpose, is fixed at the upper end by a ring adapter (67) in the area of the base of blind-hole bore (61) and at its
10 lower end by a comparable ring adapter (67) in a base plate screwed into rolling piston (50). Annular space (65) is filled with gas via a valve (68) that is situated in this base plate.

Central hollow space (62) is in a hydraulic connection to
15 bellows interior (5) via bore holes (63) and a double-acting leaf valve (64).

The second hydraulic accumulator is arranged in the area of upper outer-bell segment (31). For this purpose, outer bell
20 (30) is surrounded here by, for example, a tubular housing (41). Between this housing (41) and the exterior contour of outer bell (30) is situated a general annular space, which is divided by a tubular membrane (42) into an inner (43) and outer annular space (44). Inner annular space (43) is filled
25 with gas, see valve (45), whereas exterior annular space (44), comparable to fluid space (75) in Figure 1, communicates with bellows interior (5) via at least one leaf valve (48). Leaf valve(s) (48) in the exemplary embodiments according to Figure 2 are situated in a detachable housing (46). Interior space
30 (47) of housing (46) is connected to bellows interior (5) via working line (76).

If appropriate, spaces (44) and (62) may also be hydraulically connected to each other directly and only communicate with
35 bellows interior (5) via a double-acting leaf valve.

In contrast to Figure 1, a rubber damping element (49), as an

elastic limit stop, is located in deaerated return space (7). In addition, upper segment (51) of rolling piston (50) is furnished with a closed bore hole (52) to reduce the unsuspended mass.

5

Between the chassis and the vehicle body, the spring leg may also be arranged so as to have an outer bell attached in an articulated manner to the chassis. For this purpose, at least the contours of the rolling piston and the outer bell may be required to be adjusted to the new orientation of the rebound spring direction.

As an alternative to the exemplary embodiments described above, a spring-and-shock-absorber system is conceivable in which fluid (1) used in the system is a magneto-rheological fluid. If on hydraulic working line (76), for example, a short annular segment is surrounded by a current-excited solenoid coil, then the excited solenoid coil in combination with fluid (1) represents a variable restrictor. As the current supplied to the coil increases, the flow velocity decreases as a result of an increase in the apparent or dynamic viscosity in working line (76), as a result of which, inter alia, the damping performance of the entire system may be changed in a controlled manner.

25

Suspension device (2) depicted in Figure 3 is composed of an outer bell (30), which is configured in a cylindrical manner, and an interior piston (50). Piston (50), arranged so as to be co-axial with respect to outer bell (30), is configured as a double rolling piston. First (upper) partial piston (51) of double rolling piston (50) has exterior diameter (D_a), whereas second (lower) partial piston (55) has exterior diameter (D_b). Piston (50) made up of partial pistons (51) and (55), is axially movable within outer bell (30) having interior diameter (D_1).

35

Inside widths ($D_1 - D_a$) and ($D_1 - D_b$) between partial pistons

(51) and (55) and outer bell (30) are filled by two roll-bellows halves (12) and (13), arranged opposite each other. Roll-bellows halves (12, 13) form a differential roll bellows (11) and are made of an elastomer material that is reinforced by a fabric insert. A (first) roll bellows (12) is assigned to one partial piston (51), whereas other (second) roll bellows (13) surrounds other partial piston (55). The ends of roll-bellows halves (12, 13) are clamped, on one side, on piston (50) using clamping rings (58, 59), and, on the other side, on outer bell (30) using an exterior ring (14) next to clamping rings (17, 18) in a pressure-tight manner. The exterior ring has two tubular connectors (76, 82) for connecting to a pump and to an accumulator (not depicted); the suspension device (2) may be controlled by tubular connectors (76, 82).

Piston (50), depicted in the drawing, is configured in a hollow cylindrical manner. Its interior contains a shock absorber (80), whose tube is secured on the upper piston end by a spring ring (90). The sealing tightness between shock absorber (tube) (80) and piston (50) is realized by three O-rings (92, 94, 96). Shock-absorber rod (81) is mounted on a covering plate (86) located on outer bell (30).

If piston (50), mounted on the wheel side, moves axially in relation to chassis-side outer bell (30), then both roll-bellows halves (12, 13), located between piston (50) and outer bell (30), roll, on one side, on the exterior surface of piston (50) and, on the other side, on the interior surface of outer bell (30). The axial force resulting from the application of pressure to roll-bellows halves (12, 13) using compressed air or hydraulic fluid, is proportional to the difference between the effective roll-bellows radii of curvature.

List of Reference Numerals

	1	fluid, water-glycol solution
	2	suspension device
5	5	bellows interior
	7	return space
	9	chassis
	10	displacement device
10	11	tubular roll bellows, differential roll bellows, bellows
	12,13	roll bellows halves, bellows parts
	14	connecting sleeve
	15	tubular segment
15	17,18	clamping rings
	21,22	meniscuses
	23,24	outer walls
	25,26	inner walls
20	30	outer bell
	31	upper segment
	32	transitional piece
	33	lower segment
25	34	base
	35	adapter
	36,37	interior walls
	41	housing, tubular
30	42	membrane, hose-like
	43	interior annular space
	44	exterior annular space
	45	valve
	46	detachable housing
35	47	housing interior space
	48	leaf valve
	49	rubber damping element

	50	rolling piston, piston
	51	upper segment
	52	bore
	53	recess
5	55	lower segment
	56,57	exterior walls
	58,59	clamping rings
	61	blind-hole bore
10	62	interior hollow space, central
	63	bores
	64	leaf valve
	65	exterior hollow space, annular space
	66	tubular membrane
15	67	ring adapter
	68	valve
	69	adapter, adapter having articulated joint
	70	hydraulic accumulator
20	71	membrane
	72	gas cushion
	74	housing
	75	fluid space
25	76	working line, tubular connector
	77	choker valves, pressure stage valves
	80	shock absorber
	81	shock absorber rod
30	82	tubular connector, pump connection
	86	cover, sleeve cylinder
	88	extension of shock absorber tube
	90	spring ring
	92,94,96	O-ring
35	D1	interior diameter outer bell
	Da	exterior diameter first piston
	Db	exterior diameter second piston

ABSTRACT

A combined spring-and-shock-absorber system for supporting wheel suspensions or axles on a vehicle body has a tubular roll bellows (U-bellows) arranged between a wheel-bearing or wheel-controlling connection and a connection on the vehicle body side, the bellows being arranged between an outer bell and a rolling piston, the outer bell and the rolling piston, in each case, having at least partially varying diameters over the height of the corresponding component, and having walls that contact the tubular roll bellows. Both ends of the tubular roll bellows being sealingly secured on the rolling piston at segments having different diameters, the lower mounting section having a larger diameter than the upper mounting section. For this purpose, a tubular roll bellows is used, which is configured as a differential roll bellows, whose interior is filled with a fluid and communicates with a hydraulic accumulator supported on the chassis and/or vehicle body.

On the basis of the present invention, a combined spring-and-shock-absorber system is developed, which contains a friction-free displacement device in a thin construction.